

SECTION 72: SLOPE PROTECTION

72-1 GENERAL

72-1.01 DESCRIPTION

• Slope protection consists of rock, concrete, concreted-rock or slope paving. The type of slope protection to be used will be designated in the Engineer's Estimate, the special provisions or shown on the plans. The slope protection shall be placed in conformance with these specifications, the special provisions, and the details and dimensions shown on the plans or directed by the Engineer.

72-2 ROCK SLOPE PROTECTION

72-2.01 DESCRIPTION

• This work shall consist of placing revetment type rock courses on the slopes.
• The size of the individual pieces of rock in each class shall be as indicated in the table in Section 72-2.02, "Materials," or as specified in the special provisions. The classes of rock slope protection will be designated in the Engineer's Estimate as 8T, 4T, 2T, 1T, 1/2T, 1/4T, Light, Facing, and No. 1, No. 2 or No. 3 Backing.

72-2.02 MATERIALS

• The individual classes of rocks used in rock slope protection shall conform to the following, unless otherwise specified in the special provisions, or as shown on the plans.

GRADING OF ROCK SLOPE PROTECTION					
Method A Placement, Percentage Larger Than*					
Rock Sizes	Classes				
	8T	4T	2T	1T	1/2T
16 Ton	0-5	—	—	—	—
8 Ton	50-100	0-5	—	—	—
4 Ton	95-100	50-100	0-5	—	—
2 Ton	—	95-100	50-100	0-5	—
1 Ton	—	—	95-100	50-100	0-5
1/2 Ton	—	—	—	95-100	50-100
1/4 Ton	—	—	—	—	95-100

* The amount of material smaller than the smallest rock size listed in the above tables for any class of rock slope protection shall not exceed the percentage limit listed in the above tables determined on a weight basis. Compliance with the percentage limit shown in the above tables for all other rock sizes of the individual pieces of any class of rock slope protection shall be determined by the ratio of the number of individual pieces larger than the specified rock size compared to the total number of individual pieces larger than the smallest rock size listed in the above tables for that class.

GRADING OF ROCK SLOPE PROTECTION								
Method B Placement, Percentage Larger Than*								
Rock Size	Classes							
	1T	1/2T	1/4T	Light	Facing	No. 1	No. 2	No. 3
2 Ton	0-5	—	—	—	—	—	—	—
1 Ton	50-100	0-5	—	—	—	—	—	—
1/2 Ton	—	50-100	0-5	—	—	—	—	—
1/4 Ton	95-100	—	50-100	0-5	—	—	—	—
200 lb	—	95-100	—	50-100	0-5	0-5	—	—
75 lb	—	—	95-100	—	50-100	50-100	0-5	—
25 lb	—	—	—	95-100	90-100	90-100	25-75	0-5
5 lb	—	—	—	—	—	—	90-100	25-75
1 lb	—	—	—	—	—	—	—	90-100

* The amount of material smaller than the smallest rock size listed in the above tables for any class of rock slope protection shall not exceed the percentage limit listed in the above tables determined on a weight basis. Compliance with the percentage limit shown in the above tables for all other rock sizes of the individual pieces of any class of rock slope protection shall be determined by the ratio of the number of individual pieces larger than the specified rock size compared to the total number of individual pieces larger than the smallest rock size listed in the above tables for that class.

- The material shall also conform to the following quality requirements:

Test	California Test	Requirement
Apparent Specific Gravity	206	2.5 min.
Absorption	206	4.2% max.*
Durability Index	229	52 min.*

* Based on the formula listed below, absorption may exceed 4.2 percent if DAR is greater than 10. Durability Index may be less than 52 if DAR is greater than 24.

$$\frac{\text{Coarse Durability Index}}{\% \text{ Absorption} + 1} = \text{Durability Absorption Ratio (DAR)}$$

- Rocks, when conforming to the provisions in this Section 72-2.02, may be obtained from rock excavation of the roadway prism or other excavation being performed under the provisions of the contract, in conformance with the provisions in Section 4-1.05, "Use of Materials Found on the Work."
- Rocks shall be of such shape as to form a stable protection structure of the required section. Rounded boulders or cobbles shall not be used on prepared ground surfaces having slopes steeper than 2:1 (horizontal:vertical). Angular shapes may be used on any planned slope. Flat or needle shapes will not be accepted unless the thickness of the individual pieces is greater than 0.33 times the length.

72-2.025 ROCK SLOPE PROTECTION FABRIC

- Rock slope protection fabric shall be placed prior to placing rock slope protection, when the fabric is shown on the plans, or specified in the special provisions, or ordered by the Engineer.
- Rock slope protection fabric shall conform to the provisions in Section 88, "Engineering Fabrics," and shall be placed in conformance with the details shown on the plans and as specified in these specifications.
- Prior to placing rock slope protection fabric, the surfaces upon or against which rock slope protection fabric is to be placed, shall be free of loose or extraneous material and sharp objects that may damage the fabric during installation.
- Rock slope protection fabric shall be handled and placed in conformance with the manufacturer's recommendations and as directed by the Engineer. Rock slope protection fabric shall be placed loosely upon or against the surface to receive the fabric so that the fabric conforms to the surface without damage when the cover material is placed.
- Rock slope protection fabrics shall be joined, at the option of the Contractor, either with overlapped joints or stitched seams.
- When fabric is joined with overlapped joints, adjacent borders of the fabric shall be overlapped not less than 24 inches. The fabric shall be placed such that the fabric being placed shall overlap the adjacent section of fabric in the direction the cover material is being placed.
- When the fabric is joined by stitched seams, the fabric shall be stitched with yarn of a contrasting color. The size and composition of the yarn shall be as recommended by the fabric manufacturer. The number of stitches per inch of seam shall be approximately 5 to 7. The strength of stitched seams shall be the same as specified for the fabric, except when stitched seams are oriented up and down a slope, the strength shall be a minimum of 80 percent of that specified for the fabric.
- Equipment or vehicles shall not be operated or driven directly on the rock slope protection fabric.
- Rock slope protection fabric damaged during placement shall be replaced or repaired, as directed by the Engineer, by the Contractor at the Contractor's expense. Fabric damaged beyond repair, as determined by the Engineer, shall be replaced. Repairing damaged fabric shall consist of placing new fabric over the damaged area. The minimum fabric overlap from the edge of the damaged area shall be 3 feet for overlap joints. If the new fabric joints at the damaged areas are joined by stitching, the stitched joints shall conform to the requirements specified herein.

72-2.03 PLACING

- Rock slope protection shall be placed in conformance with one of the following methods as designated in the Engineer's Estimate.
- At the completion of slope protection work, the footing trench shall be filled with excavated material and compaction will not be required.

Method A Placement

- A footing trench shall be excavated along the toe of slope as shown on the plans.

- The larger rocks shall be placed in the footing trench.
- Rocks shall be placed with their longitudinal axis normal to the embankment face and arranged so that each rock above the foundation course has a 3-point bearing on the underlying rocks. Foundation course is the course placed on the slope in contact with the ground surface. Bearing on smaller rocks which may be used for chinking voids will not be acceptable. Placing of rocks by dumping will not be permitted.
- Local surface irregularities of the slope protection shall not vary from the planned slope by more than one foot measured at right angles to the slope.

Method B Placement

- A footing trench shall be excavated along the toe of the slope as shown on the plans.
- Rocks shall be so placed as to provide a minimum of voids, and the larger rocks shall be placed in the toe course and on the outside surface of the slope protection. The rock may be placed by dumping and may be spread in layers by bulldozers or other suitable equipment.
- Local surface irregularities of the slope protection shall not vary from the planned slopes by more than one foot measured at right angles to the slope.

72-2.04 MEASUREMENT

- Rock slope protection will be measured by the ton or cubic yard as designated in the Engineer's Estimate.
- Quantities of rock slope protection to be paid for by the cubic yard will be determined from the dimensions shown on the plans or the dimensions directed by the Engineer and rock slope protection placed in excess of these dimensions will not be paid for.
- Quantities of rock slope protection to be paid for by the ton will be weighed in conformance with the provisions in Section 9-1.01, "Measurement of Quantities."
- Rock slope protection fabric will be measured by the square yard. The quantity to be paid for will be the actual area covered not including additional fabric required for overlaps.

72-2.05 PAYMENT

- The contract price paid per cubic yard or per ton for rock slope protection (the class of rock and method of placement to be designated in the Engineer's Estimate) shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in constructing the rock slope protection, complete in place, including excavation, and backfilling footing trenches, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.
- The contract price paid per square yard for rock slope protection fabric shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in furnishing and placing rock slope protection fabric, complete in place, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.

72-3 (BLANK)**72-4 CONCRETE SLOPE PROTECTION, GUTTER LINING, DITCH LINING, AND CHANNEL LINING****72-4.01 DESCRIPTION**

- This work shall consist of constructing concrete slope protection, and concrete gutter, ditch and channel lining. At the option of the Contractor, the slope protection and linings, including footings, support walls, cut-off stubs, cut-off walls and aprons, shall be constructed of either portland cement concrete or shotcrete.

72-4.02 FOUNDATION PREPARATION

- The foundation, which includes all surfaces upon which concrete or shotcrete is to be placed, shall be evenly graded such that no point on the graded surface shall be above the designated plane. If unsuitable material is encountered at the elevation of the foundation, the material shall be removed and disposed of as directed by the Engineer. The resulting space shall be filled with material suitable for the foundation. The foundation areas shall be thoroughly compacted, with moisture sufficient to allow a firm foundation and to prevent absorption of water from the concrete or shotcrete, but shall not contain free surface water.

72-4.03 MATERIALS

- Portland cement concrete shall conform to the provisions in Section 90, "Portland Cement Concrete," and shall be either Class 3 concrete or minor concrete at the Contractor's option.
- Shotcrete shall conform to the provisions in Section 53, "Shotcrete."
- Expansion joint filler shall conform to the provisions in Section 51-1.12C, "Premolded Expansion Joint Fillers."
- Pervious backfill material shall conform to the provisions in Section 19-3.065, "Pervious Backfill Material."
- Reinforcement shall conform to the provisions in Section 52, "Reinforcement."

72-4.04 CONSTRUCTION

- Concrete shall be mixed and placed in conformance with the provisions in Section 51, "Concrete Structures," and shall be spread and tamped until the concrete is thoroughly compacted and mortar flushes to the surface. If the slope is too steep to permit the use of concrete sufficiently wet to flush with tamping, the concrete shall be tamped until consolidated, and a mortar surface, $\frac{1}{4}$ inch thick, shall be troweled on immediately. The mortar shall consist of one part portland cement and 3 parts of fine aggregate.
- After striking off to grade, the concrete shall be hand floated with wooden floats not less than 4 inches in width and not less than 30 inches in length. The entire surface shall be broomed with a fine texture hair push broom to produce a uniform surface. Brooming shall be done when the surface is sufficiently set to prevent deep scarring and shall be accomplished by drawing the broom down the slope leaving the marks parallel to the edges of the panel. If directed by the Engineer, a fine spray of water shall be applied to the surface immediately in

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advance of brooming. Edges and joints shall be edged with a $\frac{1}{4}$ inch radius edger prior to the brooming.

- Shotcrete shall be placed and finished in conformance with the provisions in Section 53, "Shotcrete."
- Expansion joints shall be installed transversely at intervals of 20 feet. Longitudinal expansion joints shall be installed if shown on the plans. Expansion joints shall be filled with expansion joint filler $\frac{1}{2}$ inch thick.
- Concrete and shotcrete shall be cured as provided in Section 90-7, "Curing Concrete."
- Pervious backfill material, if required by the plans, shall be placed as shown. A securely tied sack containing one cubic foot of pervious backfill material shall be placed at each weep hole and drain hole. The sack material shall conform to the requirements in Section 88-1.03, "Filter Fabric".
- At the completion of the work, footing trenches shall be filled with excavated material and compaction will not be required.

72-4.05 MEASUREMENT

- Quantities of concrete or shotcrete will be measured by the cubic yard computed from measurements, along the slope, of the actual areas constructed and the theoretical thickness shown on the plans. No additional compensation will be allowed for additional concrete or shotcrete placed by reason of low foundation.

72-4.06 PAYMENT

- Quantities of concrete or shotcrete measured as specified in Section 72-4.05, "Measurement," will be paid for at the contract price per cubic yard as concrete (slope protection, gutter lining, ditch lining and channel lining, as individual items, or combinations thereof).
- The above price and payment shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in shaping slopes and preparing the foundation, constructing weep holes and drain holes, furnishing and placing expansion joint filler, mortar, reinforcement, structure excavation and structure backfill, and pervious backfill material, and constructing the finished slope protection, lined gutters, ditches and channels, including support walls, cut-off stubs, cut-off walls, footings and aprons, complete in place, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.
- Except for structure excavation, excavation within the limits of payment shown on the plans will be paid for as provided in Section 19, "Earthwork." Removal and disposal of unsuitable material will be paid for at the contract price for the class of excavation designated on the plans or in the special provisions for removal of the material above the foundation elevation. The material used to replace unsuitable material will be paid for as provided in Section 19-7, "Borrow Excavation."

72-5 CONCRETED-ROCK SLOPE PROTECTION

72-5.01 DESCRIPTION

- This work shall consist of placing revetment type concreted-rock courses on the slopes.

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- The rock slope protection shall be concreted as shown on the plans and as specified in these specifications and the special provisions.
- The size of the individual pieces of rock in each class shall be as indicated in the table in Section 72-5.02, "Materials," or as specified in the special provisions. The classes of concreted-rock slope protection will be designated in the Engineer's Estimate as 1/2T, 1/4T, Light, Facing and Cobble.

72-5.02 MATERIALS

- The individual classes of rocks used in concreted-rock slope protection shall conform to the following, unless otherwise specified in the special provisions or shown on the plans.

GRADING OF CONCRETED-ROCK SLOPE PROTECTION

Rock Sizes	Percentage Larger Than*				
	Classes				
	1/2T	1/4T	Light	Facing	Cobble
1 Ton	0-5	—	—	—	—
1/2 Ton	50-100	0-5	—	—	—
1/4 Ton	—	50-100	0-5	—	—
200 lb	90-100	—	50-100	0-5	—
75 lb	—	90-100	90-100	50-100	0-5
25 lb	—	—	—	90-100	95-100
Minimum Penetration of Concrete (inches)	18	14	10	8	6

* The amount of material smaller than the smallest rock size listed in the table for any class of concreted-rock slope protection shall not exceed the percentage limit listed in the table determined on a weight basis. Compliance with the percentage limit shown in the table for all other rock sizes of the individual pieces of any class of concreted-rock slope protection shall be determined by the ratio of the number of individual pieces larger than the specified rock size compared to the total number of individual pieces larger than the smallest rock size listed in the table for that class.

- The material shall also conform to the following quality requirements:

Test	California Test	Requirement
Apparent Specific Gravity	206	2.5 min.
Absorption	206	4.2% max.*
Durability Index	229	52 min.*

* Based on the formula listed below, absorption may exceed 4.2 percent if DAR is greater than 10. Durability Index may be less than 52 if DAR is greater than 24.

$$\frac{\text{Coarse Durability Index}}{\% \text{ Absorption} + 1} = \text{Durability Absorption Ratio (DAR)}$$

- Rocks, when conforming to the provisions in this Section 72-5.02, may be obtained from rock excavation of the roadway prism or other excavation being

performed under the provisions of the contract, in conformance with the provisions in Section 4-1.05, "Use of Materials Found on the Work."

- Rocks shall be of such shape as to form a stable protection structure of the required section. Flat or needle shapes will not be accepted unless the thickness of the individual pieces is greater than 0.33-times the length.
- Concrete shall be Class 3 concrete or minor concrete conforming to the provisions in Section 90, "Portland Cement Concrete," one-inch combined aggregate and mixed as provided for structures. The water content of the concrete shall be such as to permit gravity flow into the interstices with limited spading and brooming. The amount of water used shall be that designated by the Engineer.

72-5.03 PLACING ROCK

- Rock for concreted-rock slope protection shall be placed in conformance with one of the following methods as designated in the Engineer's Estimate.
- At the completion of slope protection work, the footing trench shall be filled with excavated material and compaction will not be required.

Method A Placement

- A footing trench shall be excavated along the toe of slope as shown on the plans.
- The larger rocks shall be placed in the footing trench.
- Rocks shall be placed with their longitudinal axis normal to the embankment face and arranged so that each rock above the foundation course has a 3-point bearing on the underlying rocks. Foundation course is the course placed on the slope in contact with the ground surface. Bearing on smaller rocks which may be used for chinking voids will not be acceptable. Placing of rocks by dumping will not be permitted.
- Local surface irregularities of the slope protection shall not vary from the planned slope by more than one foot measured at right angles to the slope.

Method B Placement

- A footing trench shall be excavated along the toe of the slope as shown on the plans.
- Rocks shall be so placed as to provide a minimum of voids and the larger rocks shall be placed in the toe course and on the outside surface of the slope protection. The rock may be placed by dumping and may be spread in layers by bulldozers or other suitable equipment.
- Local surface irregularities of the slope protection shall not vary from the planned slopes by more than one foot measured at right angles to the slope.

72-5.04 PLACING CONCRETE

- The surfaces of the rock to be concreted shall be cleaned of adhering dirt and clay and then moistened. The concrete shall be placed in a continuous operation for any day's run at any one location. Concrete shall be brought to the place of final deposit by use of chutes, tubes or buckets, or may be placed by means of pneumatic equipment or other mechanical methods. In no case shall concrete be permitted to flow on the slope protection a distance in excess of 10 feet.

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- Immediately after depositing, the concrete shall be spaded and rodded into place with suitable spades, trowels or other approved means until the minimum penetration is that shown in the table entitled "Grading of Concreted-Rock Slope Protection" in Section 72-5.02, "Materials."
- After the concrete has been placed, the rocks shall be thoroughly brushed so that their top surfaces are exposed. The outer rocks shall project 0.33 to 0.25 times their diameter above the concrete surface. After completion of any 10-foot strip, no workman or load shall be permitted on the surface for a period of at least 24 hours, and longer if so ordered by the Engineer.
- Concreted-rock slope protection shall be cured as provided in Section 90-7, "Curing Concrete."

72-5.05 MEASUREMENT

- Concreted-rock slope protection will be measured by the ton or cubic yard for the rock as designated in the Engineer's Estimate and by the cubic yard for the concrete.
- Quantities of rock to be paid for by the cubic yard will be determined from the dimensions shown on the plans or the dimensions directed by the Engineer, and rock placed in excess of these dimensions will not be paid for.
- Quantities of rock to be paid for by the ton will be weighed in conformance with the provisions in Section 9-1.01, "Measurement of Quantities."
- Quantities of concrete to be paid for by the cubic yard will be measured at the mixer as provided in Section 90-11, "Measurement and Payment."

72-5.06 PAYMENT

- The contract price paid per cubic yard or per ton for concreted-rock slope protection (the class of rock and method of placement to be designated in the Engineer's Estimate) and per cubic yard for concrete (concreted-rock slope protection) shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in constructing the concreted-rock slope protection, complete in place, including excavation and backfilling footing trenches, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.

72-6 SLOPE PAVING

72-6.01 DESCRIPTION

- This work shall consist of constructing slope paving under the ends of bridges and in other locations. At the option of the Contractor, slope paving shall be constructed of either shotcrete or portland cement concrete.

72-6.02 FOUNDATION PREPARATION

- The foundation, which includes surfaces upon which slope paving is to be constructed, shall be evenly graded such that no point on the graded surface shall be above the designated slope plane. The foundation areas shall be thoroughly compacted, with moisture sufficient to allow a firm foundation and to prevent absorption of water from the concrete or mortar, but shall not contain free surface water.

72-6.03 MATERIALS

- Portland cement concrete shall conform to the provisions in Section 90, "Portland Cement Concrete," and shall be either Class 3 concrete or minor concrete at the Contractor's option. The one-inch maximum combined grading shall be used for Class 3 concrete, and the maximum size of aggregate for minor concrete shall be not larger than one-inch nor smaller than $\frac{3}{4}$ -inch.
- Shotcrete shall conform to the provisions in Section 53, "Shotcrete."
- When required by the plans or special provisions, slope paving shall be colored by mixing a fine ground, synthetic mineral oxide, specifically manufactured for coloring concrete, into the concrete or mortar mix. The coloring agent shall be uniformly and homogeneously mixed with the concrete or mortar. The color of the completed slope paving after curing and when air dry shall be tan conforming closely to Color No. 30450 of Federal Standard No. 595B.
- Reinforcement shall conform to the provisions in Section 52, "Reinforcement."
- Timber spacers shall be construction heart redwood or better, graded in conformance with the provisions in Section 57-2.02, "Grading Rules and Requirements." Nails used to fasten the timber spacers shall be hot-dip galvanized.

72-6.04 CONSTRUCTION

- Concrete slope paving shall be constructed and finished in conformance with the provisions in the first 2 paragraphs in Section 72-4.04, "Construction."
- Shotcrete slope paving shall be constructed and finished in conformance with the provisions in Section 53, "Shotcrete." After the shotcrete has been placed as nearly as practicable to the required depth, the surface shall be checked with a straightedge, and any low spots or depressions shall be brought up to proper grade by placing additional mortar. The finish of the shotcrete slope paving shall be uniform without humps or hollows of more than $\frac{1}{2}$ inch in 10 feet.
- Timber spacers shall be furnished and installed as shown on the plans. The timber spacers shall be securely held in place by anchor bars consisting of commercial quality bar reinforcing steel.
- Concrete curbs shall be constructed in conformance with the provisions in Section 73, "Concrete Curbs and Sidewalks," and shall be constructed prior to constructing sidewalks or constructing the slope paving.
- Slope paving shall be cured by the curing compound method using curing compound (6) as provided in Section 90-7.01B, "Curing Compound Method."
- The construction of the slope paving shall be scheduled so that the work, including placing, finishing and application of curing compound, is completed in any section bordered by timber spacers on the same day that the work is started in that section. There shall be no construction joints between timber spacers.
- Earthwork for slope paving, including excavation for drain trenches, shall conform to the provisions in Section 19, "Earthwork."

72-6.05 MEASUREMENT

- The quantity of concrete or shotcrete used in slope paving (concrete) will be computed from measurements, along the slope, of the actual areas constructed and the theoretical thickness shown on the plans. No additional compensation will be

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allowed for additional shotcrete or concrete placed by reason of low foundation. No deduction will be made for timber spacers.

72-6.06 PAYMENT

- The contract price paid per cubic yard for slope paving (concrete) shall include full compensation for furnishing all labor, materials (including bar reinforcing steel, reinforcing steel anchors, welded wire fabric and timber spacers), tools, equipment and incidentals, and for doing all the work involved in constructing the slope paving, complete in place (including excavation, backfill and installing timber spacers), as shown on the plans, as specified in the special provisions and these specifications, and as directed by the Engineer.
- Curbs, drain inlets, downdrains and underdrains used in connection with slope paving will be paid for as specified in the special provisions.

